REMARKS/ARGUMENTS

The Examiner has withdrawn his previous indication of allowability of claims 12-21 over newly cited references.

Claims 12, 13, 14, 17, 18, 19, 20, and 21 have been amended.

Recitation of the Invention as-claimed:

The invention, as recited in amended claims 12, 13, and 14, is directed to a method for etching oxide on a semiconductor substrate. In the method, a positive electrical charge is produced on the oxide. Then, subsequent to the positive electrical charge production, the previously positively charged oxide on the substrate is exposed to hydrofluoric acid vapor and water vapor (claim 12), methanol vapor (claim 13), or isopropyl alcohol vapor (claim 14) in a process chamber held at temperature and pressure conditions that are controlled to form on the substrate no more than a saturated monolayer of etch reactants and products produced by the vapor as the oxide is etched by the vapor. The invention also provides for the first production of a negative electrical charge, rather than a positive electrical charge on the oxide, as recited in claim 19.

Rejections of the Claims:

Claims 12 and 19-21 were rejected under 35 U.S.C. §103(a) as being unpatentable over a publication to Nakanishi in view of U.S. Patent No. 6,194,325, to Yang; U.S. Patent No. 5,922,219, to Fayfield; and U.S. Patent No. 5,006,795, to Yoshizawa.

The Examiner suggested that Nakanishi teaches a wafer cleaning method in which a mixture of HF and H_2O vapors is applied to the surface of a wafer. The

pressure and temperature are said to be controlled during the cleaning/etching process to form monolayer coverage, in an effort to achieve uniform etching.

The Examiner went on to suggest that Yang teaches a method for etching an oxide such as silicon oxide in a plasma including a RF powered negative DC bias applied to a substrate. Fayfield was said by the Examiner to teach a method for etching silicon oxide using UV radiation of the substrate. The Examiner suggested that Yoshizawa teaches that an electron beam can be used to produce a positive charge on a substrate.

Based on these characterizations of the references, the Examiner suggested that "it would been obvious to one of ordinary skill in the art at the time of the invention to bias the substrate positively or negatively in order to generate a uniform plasma, to attract ions and improve the etch rate in the well-known manner," (p. 2).

The invention as recited in the amended claims requires two distinct and separate steps; in a first step, positive or negative electrical charge is produced on oxide on a semiconductor substrate. In a second, subsequent step carried out after production of positive or negative electrical charge, the oxide is exposed to hydrofluoric acid vapor and water, methanol, or isopropyl alcohol vapor under the temperature and pressure conditions recited above. None of the cited references, considered alone or in any proper combination, teach or suggest this two-step process provided by the invention.

As explained in the instant Specification, the invention is a discovery that production of positive or negative electrical charge enables control of oxide etch rate in a given etch regime. Specifically, an "activated, high-etch rate state" is discovered to be enabled for sub-monolayer and monolayer etch regimes by a first step of electrically charging an oxide surface with a positive polarity charge prior to the etch step (p. 35, lines 26-27; p. 36, lines 4-15). For a multilayer etch regime, an activated, high-etch rate state is discovered to be enabled by first electrically

charging an oxide surface with a negative polarity charge prior to the vapor exposure (p. 35, lines 4-15). The experimental Examples 20-30 presented in the Specification provide examples of this two-step process. It is demonstrated that a first positive charging step results in an etch rate increase by a factor of about 5 (p. 42, line 22-23) and similarly, a first negative charging step results in a significant enhancement of etch rate (p. 46, lines 6-7).

The Nakanishi article describes an HF/H_2O vapor etch process, in which oxide is exposed to HF/H_2O vapor (p. 255, col. 1). No electrical charge, positive or negative, is produced on the oxide by Nakanishi's process. Nakanishi does not teach or suggest the use of any step at all prior to the vapor exposure, and does not suggest that any such step should be considered for any reason, let alone to impact the etch rate resulting from vapor exposure.

Yang teaches a conventional oxide plasma etch process. In this process, an RF bias power is applied to the electrode on which a substrate is supported, with a bias of several hundred volts applied to the substrate (col. 6, lines 11-21). But this conventional biasing does not result in production of charge on the oxide as required by the claims. As explained in the instant Specification, if a plasma charging process is to be employed to produce a charge on an oxide layer, a substrate on which the oxide layer is provided must be insulated from the plasma RF electrode, e.g., with Kapton tape, so that the metal electrode and insulated substrate form a capacitor, so that the substrate is capacitively biased, whereby electrostatic charge is accumulated on the oxide layer surface, here configured as one plate of the capacitor (p. 37, lines 8-21). This capacitive coupling bias has been explicitly called out in the amended claims 18, 20, and 21.

In a conventional plasma processing configuration like that of Yang, the substrate is not electrically insulated from the electrode, and charge therefore cannot accumulate on the substrate or layers provided on the substrate - the substrate remains electrically neutral, with no excess positive or negative charge. In fact, it is well known that such charge accumulation is to be avoided; a charged

layer may not etch uniformly or predictably. The Examiner stated that it would be obvious to bias a substrate in order to generate a uniform plasma. The generation of a plasma by application of a voltage to an electrode is not the same as producing a net positive or negative charge on a substrate - the substrate remains electrically neutral in Yang's configuration of an RF voltage for producing a plasma. Thus, it is clear that Yang's conventional plasma etch process cannot produce a positive or negative charge on oxide provided on a substrate as required by the claims, and Yang of course does not suggest such.

There is no motivation to combine the Yang plasma etch process with Nakanishi's vapor etch process. Each of these processes is provided for etching oxide in a dramatically different fashion. There simply is no technological motivation for using both the plasma and the vapor etch processes together; the use of HF vapor has no known ability to improve a plasma etch process, and Yang's conventional plasma etching has no known ability to improve an HF vapor etch process.

In addition, neither Yang nor Nakanishi provide a teaching or suggestion of how to produce a charge on oxide to be etched, and neither even hint at the use of a first step of producing a charge on oxide to be etched. No combination of the Nakanishi and Yang processes supply this missing step, and no combination provides a two-step process of oxide charging and then vapor exposure as required by the claims.

Turning to the Fayfield process, here an oxide layer on a substrate is first exposed to a flow of halogen gas while being illuminated with UV light, and then the oxide layer is etched, e.g., by exposure to HF/IPA vapor (col. 6, lines 22-25). The UV light exposure in Fayfield's process does not produce positive or negative electrical charge on the oxide layer as required by the claims, and no combination of the Fayfield process with the other references produces this missing requirement.

As explained in the instant Specification, if UV light is to be employed to produce a positive oxide charge, then an electrically biased metallic screen is required to actually cause a net positive charging of the oxide (p. 36, line 27 - p. 37, line 7). Claim 17 has been amended to explicitly point out that the metallic screen is electrically biased. It is well-understood that the application of UV light alone as employed by Fayfield does not produce a positive charge on oxide. The UV light energetically excites electrons at the oxide surface, but the electrons remain in the oxide, maintaining electrical neutrality of the oxide.

The inventors herein have discovered that when a metallic screen is positioned over the oxide surface and is electrically biased in accordance with the invention, the screen attracts energetically excited electrons, causing electrons to leave the oxide surface and rendering the oxide with a net positive charge. Without the some mechanism that causes electrons to actually leave the oxide surface, the oxide would remain electrically neutral as in the Fayfield process.

Fayfield does not teach or suggest any mechanism for attracting energetically excited electrons to leave an oxide surface. Fayfield suggests that his UV illumination step is employed to establish a uniform surface condition prior to an etch step (col. 3, lines 30-36). This technique is well-known for its use in decomposing any organic matter that may be present on a surface to be etched. Nowhere does Fayfield teach or even suggest how his UV illumination could be employed to impart a positive electrical charge on an oxide surface, and his process does not inherently do so. As explained above, without the use of some mechanism for causing electrons to leave the oxide surface, UV illumination alone does not inherently impart a positive charge on a surface.

No combination of Fayfield and Nakanishi provides the step of producing a charge on oxide to be etched as required by the claims, and together they fail to teach the two-step process of the invention of producing a charge on oxide and then exposing the charged oxide to etch vapor.

Finally, the Yoshizawa process describes an electron beam apparatus that can be employed for making measurements of patterns on a semiconductor substrate. The direction of an electron beam to the surface of a substrate causes the generation and emission of secondary electrons by material on the substrate, and renders a positive or negative charge on the surface (col. 4, lines 1-18). Detection of emitted secondary electrons is employed by Yoshizawa to enable measurement of the "wiring width" of patterns on a substrate (col. 5, lines 1-21).

Yoshizawa's process is solely limited to making measurements of patterns; no other method is taught or suggested. Yoshizawa does not teach or suggest any oxide etch process at all; let alone a reason for electrically charging a substrate prior to an etch process. Nakanishi teaches only an oxide etch process, and also fails to teach or suggest an oxide charging step to be carried out prior to an etch process. There is no motivation of any kind to combine the Nakanishi and Yoshizawa processes - one is concerned with pattern measurement and the other with oxide etching. The Examiner himself does not identify any motivation for employing the Yoshizawa electron beam process with Nakanishi's etch step.

But it is well held that a motivation to combine references must be presented: "The showing of a motivation to combine [references] must be clear and particular, and it must be supported by actual evidence," *Teleflex, Inc. v. Ficosa North American Corp.*, 299 F.3d 1313, 63, USPQ2d 1374 (Fed. Cir. 2002). The Examiner's statement that "it would be obvious...to bias the substrate positively or negatively in order to generate a uniform plasma, attract ions and improve the etch rate" has no relevance to Nakanishi's vapor etch process, which does not employ a plasma, and has no relevance to Yoshizawa's electron beam pattern measurement process, which likewise does not employ a plasma and further which is not an etch process. There simply is no technological motivation to combine these references, none is supplied by either of the references, and the Examiner has failed to identify or suggest any such motivation.

Without a presentation of actual evidence of a motivation to combine the Nakanishi vapor etch process with the Yoshizawa pattern measurement process, the Examiner is engaging in inappropriate hindsight recreation of the invention. One cannot "pick and choose among the individual elements of assorted prior art references to recreate the claimed invention," but rather, must "look for some teaching or suggestion in the references to support their use in the particular claimed combination," *Symbol Technologies, Inc. v. Opticon, Inc.*, 935 F2d 1569, 19 USPQ2d 1241 (Fed. Cir. 1991). There is absolutely no teaching or suggestion by Nakanishi or Yoshizawa to combine a pattern measurement technique with an HF vapor etch technique. Neither supplies even a hint of recognition of the discovery of the invention that an initial oxide charging step can be employed to alter the oxide etch rate. The application of a combination of Nakanishi and Yoshizawa teachings is therefore respectfully submitted to be incorrect.

The Applicants submit that none of the cited references, considered alone or in any proper combination, teach or suggest the two-step process of the invention of producing a charge on oxide and then exposing the charged oxide to etch vapor.

Claims 13-18 were rejected under 35 U.S.C. §103(a) as being unpatentable over the publication to Nakanishi in view of U.S. Patent No. 5,336,356 to Ban and the Yang, Fayfield, and Yoshizawa patents discussed above.

The Examiner suggested that Ban teaches a method for oxide layer removal using HF vapor and a solvent, such as methanol or isopropyl alcohol. The Examiner went on to suggest that a combination of Ban and Nakanishi, in combination with Yang, Fayfield, or Yoshizawa, in the manner described above, teaches the invention of claims 13-18.

Claims 13-18 all include the limitations described above, that is, claims 13-18 all require the two-step process of the invention of producing a charge on oxide and then exposing the charged oxide to etch vapor. For any etch vapor suggested by Ban, no proper combination of Nakanishi, Ban, Yang, Fayfield, or Yoshizawa

teaches this two-step process required by the claims. As explained above, Nakanishi, like Ban, teaches only a vapor etch technique. Yang teaches conventional plasma etching that does not produce an oxide charge. Fayfield teaches a UV cleaning process and HF vapor etch that does not produce an oxide charge. Yoshizawa teaches an electron beam pattern measurement technique that does not make a hint or suggestion as to how or why such could be employed for charging oxide to be etched. Therefore, no combination of the references provides the required oxide charging and vapor etch steps required of claims 12-21. The Applicants therefore submit that the claims are in condition for allowance, which action is requested.

If the Examiner has any questions or would like to discuss the claims, he is encouraged to telephone the undersigned Agent directly at his convenience at the phone number given below.

Respectfully submitted,

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